It remained for an eastern State to report the greatest damage from a single hailstorm in 1929. This was a million-dollar loss at and near Hartford, Conn., on August 1, and the greater part of the damage was to greenhouses and the tobacco crop.

A hailstorm in Illinois on May 1 that extended from Cora to Raleigh caused a loss of $720,000. The hail was so severe that roofs were pierced, windows broken greenhouses practically demolished, and fruit ruined over a path 2 to 6 miles wide and 6 miles long. * * *

PRELIMINARY STATEMENT OF TORNADOES IN THE UNITED STATES DURING 1929

By HERBERT C. HUNTER

[Weather Bureau, Washington, January 30, 1930]

In advance of the final study of the 1929 windstorms which is expected to be finished during the coming summer, the following preliminary statement, compiled from the material thus far available from section directors and others, is presented:

TORNADOES AND PROBABLE TORNADOES

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Number	5	5	17	60	37	11	6	4	7	2	0	4	158
Deaths	9	23	20	168	35	2	0	0	0	1	----	0	258
Damage [1]	10	160	352	4,824	1,408	733	32	151	2	4	----	6	7,682

TORNADIC WINDS AND POSSIBLE TORNADOES [2]

Number	1	0	4	5	3	2	2	0	0	3	0	0	20
Deaths	4	----	0	0	3	0	0	----	----	0	----	----	7
Damage [1]	1,250	----	20	20	50	2	(3)	----	----	5	----	----	1,347

[1] In thousands of dollars. [2] Several of these, in the final study, will probably be classed as not tornadoes. [3] No estimate of the damage was obtained for either.

CYCLE RECURRENCES WITH VARIABLE LENGTH OF BOTH PERIOD AND AMPLITUDE [1]

551.501

By CHARLES F. MARVIN

[Weather Bureau, Washington, January 18, 1930]

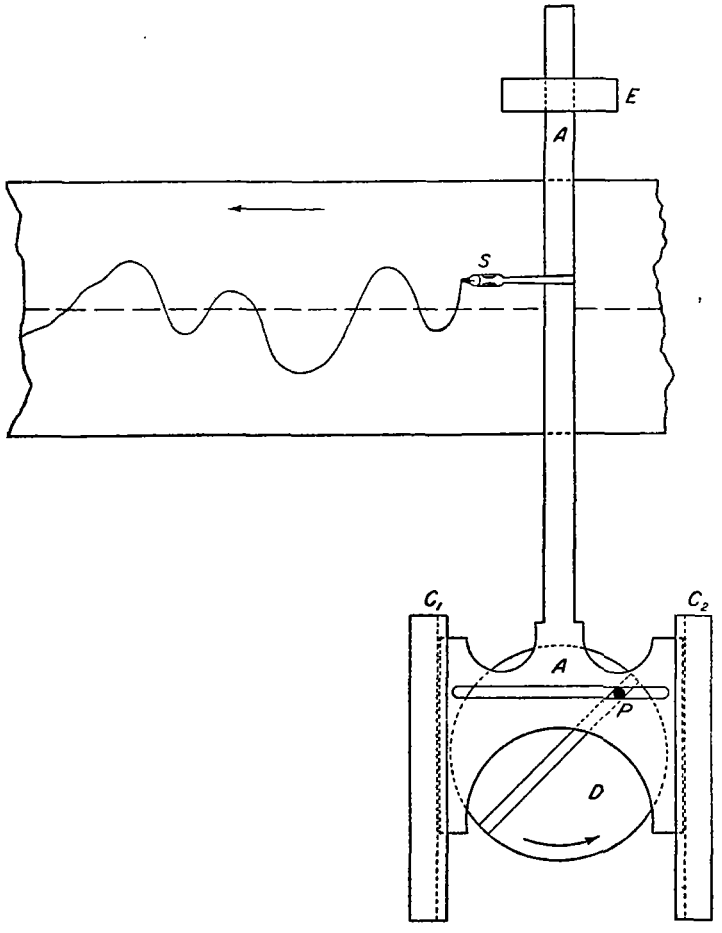

FIGURE 1.—Harmonic analyzer

Following a bit further our interesting discussions of yesterday, concerning cycles and periodicities, I think I would like to state in writing briefly what I tried to make clear in our conversation regarding my conception of the geometrical background or basis for cycle recurrences with variable lengths of both period and amplitude. These conceptions have been in my mind for a great many years, in fact ever since our associate, Mr. Clough, began to advocate his theory of handling periodicities with various lengths and amplitudes.

I think that what I have to say can be made most clear by aid of the accompanying diagram (fig. 1), in which D is a disk revolving about its center, with a movable crank pin, P, which can be either fixed in any desirable position in the slot across the top of the disk, or it can have independent movement to or fro in the slot, either from the center outward in one direction, or from one side of the disk to the opposite, etc. The plate AA is carried between lateral guides, C_1C_2 to the guide at E. This plate carries a stylus, S, for tracing movements of the plate. The crank pin, P, engages a slotted opening in the plate A, and, when the disk D is rotated, gives lineal harmonic motion to the plate A and the stylus S. If, now, a band of paper is moved continuously forward under the stylus S, a record is traced of the combined movements of the paper and of the stylus. When the crank pin retains a fixed position and D is revolved at a uniform rate we have uniform motion of a point in the circle which traces out the conventional trigonometric curve on the paper. It is obvious, however, that if the rotation of the disk D is not uniform but executed in an accelerated and decelerated manner the period of the harmonic curve traced out will be variable and not constant. It is equally obvious that if

[1] This paper was prepared in the form of a letter to Dr. A. E. Douglass, University of Tucson, Tucson, Ariz.

the rotation of D is made constant and the movement of the paper is made variable, the same result will be secured. Finally, if the crank pin itself independently changes its radial distance from the axis of D, the amplitude of the curve will be modified, and if in this motion of the crank pin, P, it passes across the center of the revolving disk, D, the effect on the trace is as if the phase of the harmonic trace had changed 180°.

The equation proposed by Fujiwhara[2] is

$$x = A(t) \sin \frac{2n}{P(t)} (t + e(t)).$$

This, so far as I know, is the first effort any of the mathematicians have made to analyze the problem of periodicities with variable length and amplitude. As soon as this paper came to my attention, my mechanical device for tracing variable periodicities led me to point out the fact that Fujiwhara's equation has a redundancy of variables, especially if he makes the phase variable. To do the latter in my mechanical model means that the crank pin, P, must have not only radial motion but also circumferential motion, and we then at once have any particular position of the stylus, S, defined by two or more possibilities, namely, acceleration or deceleration of the disk, coupled with either change of radius or change in the circumferential position of the crank pin. This concept of variable phase angle impresses me as an undesirable redundancy in Fujiwhara's equation, and I would replace that term by a constant phase angle.

[2] Jour. Faculty of Sci. Imp. Univ. of Tokyo. Sec. 1, vol. 1, pt. 10, p. 392.

I have already mentioned that variation in the length of the period can be secured either by accelerating and retarding the forward motion of the paper on which the record is traced, or retaining uniform forward motion for the paper variable lengths of period result from acceleration and retardation of rotation of D. We are, therefore, at liberty to choose either one of these.

Finally, I mentioned that if the radial motion of the crank pin carries it across the center of D it has the effect of sudden change of phase of 180°. I therefore imagine our conception of these periodic curves in nature is best represented by radial motion of the crank pin only from the center outward, although some writers seem to claim they constantly find the phase of their cycle curves change 180°. If this is actually the case in nature it is represented in the mechanical model in the way I have indicated.

You can see, of course, that with only one disk and one slide "A," any curve can be represented by movements of the crank pin in and out from the center, combined with variable paper on disk speeds. This is a vastly simpler concept of periodic motions in nature than to suppose such natural periodicities are made up of a multitude of harmonic elements. However, I think we should not require one mechanical model of this kind to represent all the details of a complex periodic curve, but rather the problem is to find a comparatively few elements having individual and separate variable amplitudes and periods of their own, which in combination produce the complex curve nature gives us.

THE WEATHER OF 1929 IN THE UNITED STATES

551.506 (73)

By ALFRED J. HENRY

Temperature, Chart 1.—Area alone considered, the year must be ranked as a moderately cool one, largely due to low temperatures in parts of the country in January, February, April, May, and September; in both Atlantic and Pacific coast States, however, mean temperature was above normal and there was also a small area of above-normal temperature in the Southwest as shown by the chart. The departures from normal rarely equaled or exceeded 2° F. (See Table 1.).

Precipitation, Chart 2.—The outstanding feature in the distribution of precipitation was the severe drought in Pacific coast and Plateau States, which happily ended in December in that region, southern California alone excepted, and it has since ended there.

The South Atlantic States and both Alabama and Tennessee experienced the second year of excessive precipitation, Tennessee excepted. The heavy precipitation in the South Atlantic and East Gulf States was due in great measure to the occurrence of two tropical cyclones within a short space of time. (See Table 2.) Following is quoted from Weekly Weather and Crop Bulletin of January 14, 1930:

> During the growing season there were two outstanding adverse conditions with regard to rainfall. Too much moisture was harmful in the early spring in most central valley sections and greatly delayed the planting of corn; later in the season, especially during the latter part of July and in August, many sections had damaging drought. The latter was most severe between the Mississippi River and Rocky Mountains, but was generally widespread in character, and, as a result spring planted crops were rather widely damaged. * * *